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METHOD FOR THE DYNAMIC ADAPTATION OF THE SUPPORT OF THE BODY OF A PERSON SEATED ON A VEHICLE SEAT AND VEHICLE SEAT FOR THIS PURPOSE

The invention relates to a method for the dynamic adaptation of the support of the body, in particular the lateral support, of a person seated on a vehicle seat, in accordance with the preamble of Patent Claim 1, and a vehicle seat with adaptive body support, in particular lateral support, according to the preamble of Patent Claim 10.

A known vehicle seat (DE 35 41 537 A1) which is controlled dynamically has inflatable air cushions for supporting the body of a person seated on the seat, which cushions are integrated as shoulder supports in the upper part of the backrest, as a side support in the right-hand and left-hand sides of the backrest, as a lumbar support, as a side support of the seat cushion on the right and left and as right-hand and left-hand supports for the thighs in the seat upholstery and in the backrest upholstery. Each air cushion is connected to a valve unit. The valve units are actuated by a CPU (central processing unit). Sensors for measuring the driving velocity of the vehicle, the lateral acceleration of the vehicle, the inclination of the vehicle and a rotational angle on the steering wheel supply corresponding measurement data to the CPU, which themselves control the filling or venting of specific air cushions via the valve units as a function of the driving situation and the driving style. In order to provide support when a lateral acceleration occurs, such as is produced, for example, when the vehicle turns, the CPU

predicts the magnitude of the lateral acceleration which will be exerted on the driver by reference to the instantaneous vehicle velocity and the rotational angle supplied by the sensor on the steering wheel, and actuates the valve devices for the air cushions, bringing about the lateral support, in the seat upholstery and backrest upholstery in such a way that the air cushions are filled with a pressure which corresponds to the degree of predicted lateral acceleration.

In a known method for adapting, as a function of the driving situation and driving style, the lateral support of a person seated on a vehicle seat (DE 197 50 223 A1), the lateral acceleration which acts on the seat and which is measured with a lateral acceleration sensor, is determined as a reference variable for the adaptation of the lateral support of the seated person. In order to take the lateral acceleration sensation of the seated person into account to a greater degree and thus generate a more comfortable sitting sensation with the advantages of a lateral holding which is necessary and built up at short notice in bends, the measured instantaneous lateral acceleration is weighted with the measured instantaneous driving velocity of the vehicle and a control variable for the degree of adaptation and/or the degree of lateral support is derived therefrom.

A known vehicle velocity control device (DE 42 01 142 A1) has a vehicle navigation system, for example GPS, which indicates the location of a vehicle on a stored digital road map which is represented on a screen. The road map supplies information on the

road section which is currently being travelled along, said information including bends which are present. The vehicle velocity control device receives information on a bend lying ahead on a road, for example on the radius of curvature of the bend on which the vehicle is travelling, and calculates the vehicle limiting velocity with which the vehicle can travel on the outside of the bend and travel safely through the bend. This vehicle limiting velocity is compared with the instantaneous vehicle velocity. If the instantaneous vehicle velocity is higher than the limiting velocity, a warning is output to the driver or velocity-reducing measures are automatically initiated.

The invention is based on the object of configuring a method of the type mentioned at the beginning in such a way that the inertia of the adaptation system used to adapt the body support on the seat is compensated.

This object is achieved according to the invention by means of the features of Patent Claim 1.

The method according to the invention has the advantage that a seat setting for adapting the body support to an adaptation event which occurs and which requires adaptation, for example travelling through a bend, is not carried out reactively, that is to say only when the adaptation event occurs, but rather is carried out proactively so that the seat setting has already experienced the necessary change when the adaptation event starts. In this way, the delay, inherent in any adaptation system, between the actuation of the adaptation system and the

changing of the seat is compensated. The method is thus no longer reliant on sensing and measuring driving manoeuvres which occur but rather adapts to the seat even if the measurements have still not supplied any clear results. The measurement results are then required only to correct the seat setting which has been carried out, there being only slight adjustment paths which can be overcome virtually without delay. By predicting the degree of necessary seat adaptation from the course of the road and the current vehicle data, the adaptation system can be conditioned with virtually any desired pre-travel and the support of the body can gradually be adapted to the required degree in a way which is virtually imperceptible to the seated person.

Expedient embodiments of the method according to the invention with advantageous developments and improvements of the invention are given in Patent Claims 1 to 9. A vehicle seat with an adaptive body support in which the method according to the invention is implemented is given in Claim 10. Advantageous embodiments of the vehicle seat are contained in the further Claims 11 to 13.

The invention is described below in more detail with reference to an exemplary embodiment illustrated in the drawing. The drawing shows here a perspective view of a driver's seat for a passenger car with the adaptation system illustrated in the block diagram and controller for the adaptation system.

The driver's seat 10 for a passenger car illustrated in a perspective view in the drawing as an exemplary embodiment of a

generic car seat, has an upholstered seat part 11 and an upholstered backrest 12 with headrest 13 projecting therefrom. An adaptation system 18 which is integrated into the vehicle seat 10 permits the upholstered contours of the seat part 11 and backrest 12 to be changed in such a way that the body of a seated person in the driver's seat 10 is supported in an optimum fashion. The adaptation system 18 described here has been limited to providing lateral support to the body, in particular when cornering, for which purpose the adaptation system 18 has air cushions 14, 15 and 16, 17 which are each integrated in side bulges of the seat part 11 and backrest 12. If the air cushions 14 to 17 are completely inflated, a maximum lateral support of the driver in the pelvic area and back area is achieved, which support can be reduced as the air pressure in the air cushions 14-17 is decreased. However, above and beyond the lateral support, shoulder support can also be provided in the upper part of the backrest, lumbar support can be provided in the lower region of the backrest and thigh support can be provided in the front region of the seat part 11, for which purpose, air cushions are also integrated into the corresponding upholstery sections, as is described, for example, in DE 35 41 537 A1.

In order to fill or vent the air cushions 14 to 17, the adaptation system 18 has a compressed air pump 20, a compressed air reservoir 21 and a compressed air regulating device 22 which is connected thereto. The compressed air regulating device 22 comprises a pressure controller 23 which switches the compressed air pump 20 in order to keep a constant excess pressure at the

input end, and a solenoid valve block 24 which is capable of applying the input pressure specifically to the four air cushions 14 to 17. The pressure regulator which is integrated in the solenoid valve block 24 also provides the possibility of reducing the pressure in the air cushions 14 to 17 by venting. The adaptation system 18 is controlled by a control unit 19 which has a central control computer 25 which accesses the solenoid valve block 24 directly, and processing blocks 26 to 29 which are controlled by the control computer 25. Two sensors 30 and 31 are connected to the control unit 19, the sensor 30 measuring the current vehicle velocity v and the sensor 31 measuring the current lateral acceleration b acting on the vehicle seat. A weighting algorithm, which describes the relationship between the vehicle velocity v and the lateral acceleration "sensed" by the driver is stored in the block 26. The current lateral acceleration b is transformed into a "sensed" lateral acceleration with this algorithm. This allows for the phenomenon according to which the driver accepts a high degree of lateral acceleration at a low velocity without desiring lateral support and considers a lateral support desirable at a high velocity even for small lateral acceleration values to be taken into account. A first characteristic curve, which predefines linking of "sensed lateral acceleration" and a degree of single-sided lateral support determined desirable for it, is stored in block 27. The "sensed lateral acceleration" is determined from the currently measured lateral acceleration b and the currently measured vehicle velocity v in block 26, and a control variable, which is

fed as an electrical signal from the central control computer 25 of the pressure regulating device 22 - and there to the solenoid valve block 24 - for setting the output pressure is formed from the characteristic curve in block 27 using said “sensed lateral acceleration”.

The driving style of the vehicle driver is classified in block 28, as described, for example, in DE 44 01 416 A1. A second characteristic curve, which predefines linking of driving style and a degree of lateral support which is determined desirable for it is stored in block 29. A supplementary control variable, which is in turn fed, as an electrical signal, from the CPU 25 to the solenoid valve block 24, which sets an appropriate output pressure, is read out of this characteristic curve in the block 29 by means of the classification result from block 28. The supplementary control variable leads to the pressure level being set in the adaptation system 18, which is applied in all four air cushions 14 to 17 in the driver's seat 10 when the solenoid valve block 24 is actuated, and results in a basic measure of lateral support in the seat 10, adapted to the driving style of the driver. After this basic pressure has been set in all air cushions 14 to 17, the solenoid valves are moved to their pressure holding position in the solenoid valve block 24 by the CPU 25.

During cornering, the control variable determined as described above is fed from the block 27 to the CPU 25. In the CPU 25, the control variable and the supplementary control

variable are linked and the electrical signal which is fed to the solenoid valve block 25 brings about, in the adaptation system 18, a compressed air setting which corresponds to the superimposition of the control variable and supplementary control variable. Depending on the direction of the current lateral acceleration b, the CPU 25 actuates the corresponding solenoid valves in the solenoid valve block 24. As a result, the pressure in the two air cushions 14 and 16 or 15 and 17, lying on the outside on the bend, of the seat part 11 and the backrest 12 is adjusted to the higher air pressure, while the pressure level in the two other air cushions lying on the inside of the bend continues to correspond to the basic pressure set on the basis of the driving style of the driver which has been determined.

In order to compensate the inertia which is inherent in the adaptation system 18 and to eliminate the delays between the measuring of the current lateral acceleration b and the setting of the air cushions 14 to 17, a prediction device 32 for determining in advance the value of the lateral acceleration to be expected on a current curve and a prediction filter 33 is connected downstream of the prediction device 32 are provided, said prediction filter 33 being connected at the output end to the control unit 19 and applying the predicted lateral acceleration value, supplied by the prediction device 32, to the control unit 19 taking into account the filling pressure-dependent filling times of the adaptation system 18.

In a first exemplary embodiment, the prediction device 32 has a vehicle navigation system and a digital road map which contains route data relating to a traffic network and, if appropriate, also attribute data assigned to the route data. It is possible to use, as an example of such a prediction device, the vehicle velocity control device described in DE 42 01 142 A1, which obtains, from the digital road map, information relating to a curve lying ahead and to its attributes, for example its radius of curvature, and calculates with the vehicle data a vehicle limiting velocity with which the vehicle can travel on the outside of the bend and can travel safely through the bend. This vehicle velocity control device can predict without difficulty the lateral acceleration which is to be expected in the bend and which acts on the vehicle given the current vehicle velocity. The current vehicle velocity is fed to the prediction device 32 and to the prediction filter 33 by the vehicle velocity sensor 30.

The method to be followed for the dynamic adaptation of the lateral support of the person seated on the front seat passenger seat will be described below with reference to the example of a bend which is to be travelled through.

The expected lateral acceleration which acts on the seated person on the bend is predicted, at a relatively large distance before the bend, from the data which is obtained from the stored road map and relates to the course of the current road and the current vehicle data which is projected onto the course of the

road. The predicted acceleration is transmitted to the control unit 19 and there to the processing block 26 via the prediction filter 33, taking into account the filling pressure-dependent delay time of the adaptation system 18 which is inherent in the system and the instantaneous vehicle velocity which is output by the sensor 30. At this time, an acceleration value which has been output by the sensor 31 is still not present at the control unit 19. As already mentioned, the predicted value of the lateral acceleration is transformed into a "sensed lateral acceleration" and the degree of single-sided lateral support is determined in the block 27 with this "sensed lateral acceleration" and a corresponding control variable is transmitted to the CPU 25. The CPU 25 transmits a corresponding electrical control signal to the pressure regulating device 22 which changes the filling pressure in the right-hand or left-hand air cushions 14, 16 or 15, 17 of the seat cushion 17 and backrest 12. Thus, a seat presetting is already carried out for the lateral support at the time at which the vehicle travelled into the bend, and the lateral acceleration measured at that time by means of the acceleration sensor 31 is then used just to perform a fine correction of the seat presetting by minimum inflation or venting of the air cushions 14 to 17.

The prediction device 32 which is described may additionally be used to signal to the driver in a haptic fashion that the curve ahead is being approached at too high a driving velocity. For this purpose, the maximum value of the lateral acceleration occurring during the travel through the curve is

determined from the limiting velocity determined in the prediction device 32 and compared with the predicted lateral acceleration. If the predicted lateral acceleration exceeds the maximum value determined, a control signal is fed to the CPU 25 via a direct control signal line 34 between the prediction device 32 and the CPU 25, said control signal being converted by the CPU 25 into a control signal for the pressure regulating device 22 in such a way that a high filling pressure is suddenly applied to the lateral air cushions 14 and 16 or 15 and 17 and indicates to the driver in a haptic fashion that the bend is being approached too quickly. Depending on the direction of curvature of the bend, the air cushions 14, 16 or 15, 17 which are arranged on the side of the vehicle seat 10 lying on the outside in the direction of curvature are filled.

In a further exemplary embodiment, the prediction device 32 can also be modified to the extent that actions of the seat setting or seat adaptation are stored in the digital road map as what is referred to as a learning map. Here, for example, salient points at which pressure changes were made in the air cushions 14 to 17 at a measured vehicle velocity during the first journey are stored in a relationship with the route data as further attributes, referred to as adaptation attributes below. For this purpose, as indicated by dashed lines in the drawing, the control signal which is generated for the compressed air regulating device 22 by the CPU 25 is also fed to the prediction device 32 so that the occurrence and the magnitude of the control signals are stored as location points for seat changes in the learning

road map. When the route section is travelled along again, these adaptation attributes are then also used by the prediction filter 33 to determine the time of an action by applying a predicted value of the lateral acceleration to the block 26 of the control unit 19. In addition, it is also possible to store the predicted lateral acceleration, referred to the velocity together with the route data, in the learning road map. When the same route section is travelled along again, a lateral acceleration which has already been predicted can thus be accessed again, and then only needs to be converted with respect to the current vehicle velocity.

In an alternative embodiment of the prediction device 32 and prediction filter 33, the prediction filter 33 is directly connected to the CPU 25 by a further control signal line 35 which is indicated by dashed lines in the drawing. In this case, the filling pressures which are applied to the air cushions 14 to 17 by the CPU 25 via the pressure regulating device 22 are stored in a velocity-corrected fashion, for example as a pressure changing point or pressure level, in the learning road map in a relationship with the route data. When the same route section is travelled along again, the stored pressure levels are then applied directly as predicted pressure levels, scaled with the current vehicle velocity, to the CPU 25 to form the prescribed set point pressure value, said CPU 25 then itself actuating the pressure regulating device 22 in order to set the set point pressures in the air cushions 14 to 17.

The invention is not restricted to the described exemplary embodiment of an adaptation system 18 embodied as a pneumatic system. In theory, any adaptation system which changes the lateral contour of the vehicle seat 10 can be used. The described method is also not restricted to implementing lateral support of the driver or further vehicle occupants during cornering. It is also possible to change the lumbar support or the support of the thighs in the seat cushions as functions of the expected course of the road section which is currently being travelled along, for example in the road sections with severe negative or positive gradients.